

Decision Support Framework for Placement of BMPs in Urban Watersheds

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The Issue

Various structural and non-structural stormwater best management practices (BMPs) have become the national focus for the mitigation of stormwater pollution. Analytical tools are needed to help agencies evaluate management options and optimize cost. Currently there is no comprehensive modeling system available in the public domain for systematically evaluating the location, type, and cost of wet-weather flow BMPs.

- Urban land increased by 330% and paved road mileage by 280% between 1945 and 1997.
- When the percentage of impervious cover exceeds 25 to 30% of the watershed, streams tend to no longer support diverse fish and aquatic life.

Abstract

To assist stormwater management professionals in planning for best management practices (BMPs) and low-impact developments (LIDs) implementation, USEPA is developing a decision support system, called the Integrated Stormwater Management Decision Support Framework (ISMDSF). This tool will help develop, evaluate, select, and place BMP/LID options. The ISMDSF, a generic public domain framework, will provide a thorough, practical, and informative assessment of management alternatives considering the economic, environmental, and engineering factors.

The ISMDSF has seven key components: framework manager, ArcGIS interface, watershed model, BMP model, optimization model, post-processor, and Microsoft Access database. They are integrated under a common ArcGIS platform.

Objective

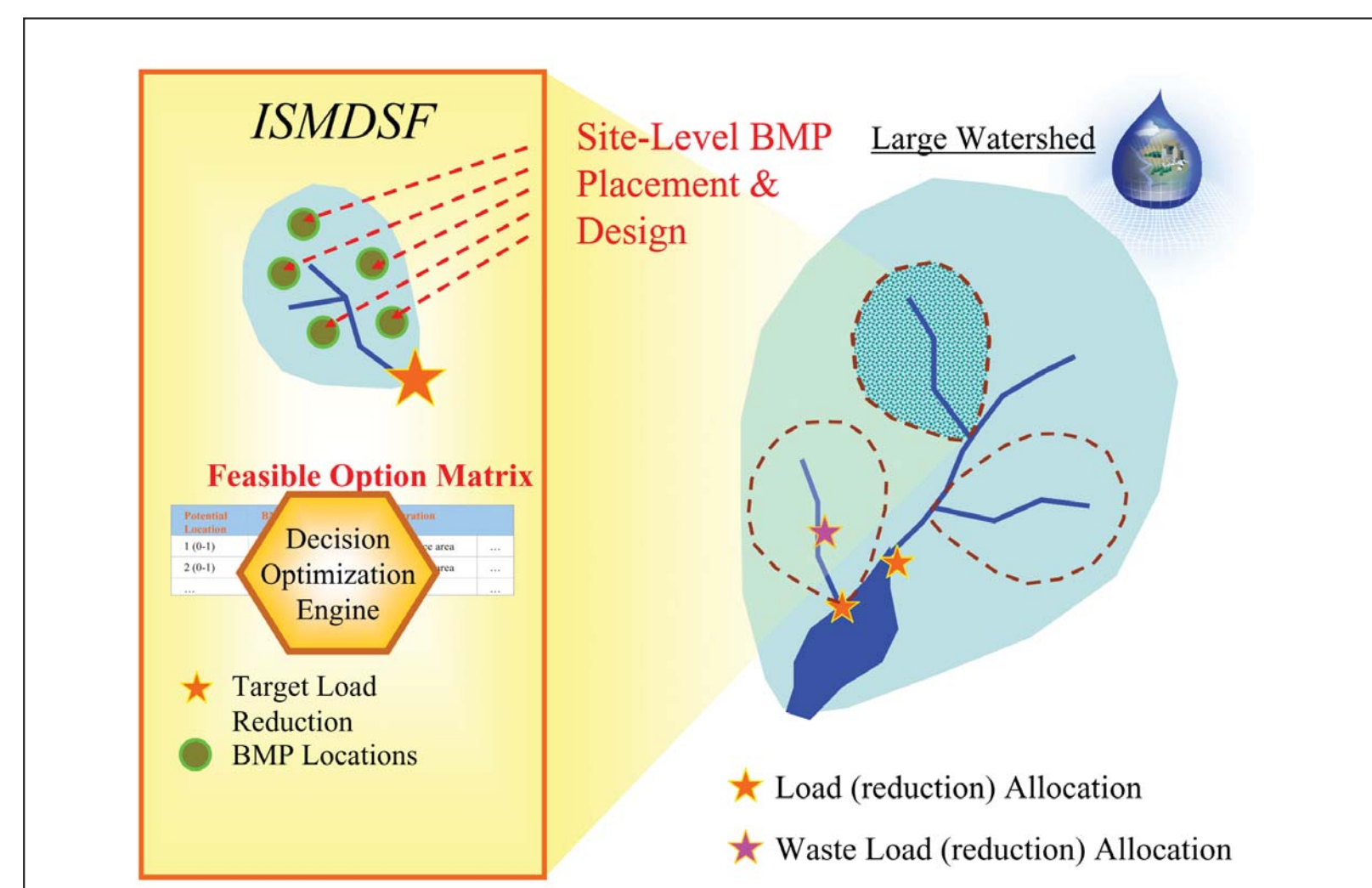
To develop methodologies and decision support tools that help develop, evaluate, select and place BMPs in urban watersheds based on sound science and consideration of cost and effectiveness.

Intended Users

Those who have a fundamental understanding of watershed and BMP modeling processes - local and county government engineers/planners, federal/state regulatory reviewers, private consulting engineers, concerned citizens, stakeholders, and academicians.

Watershed-based Placement Scenario

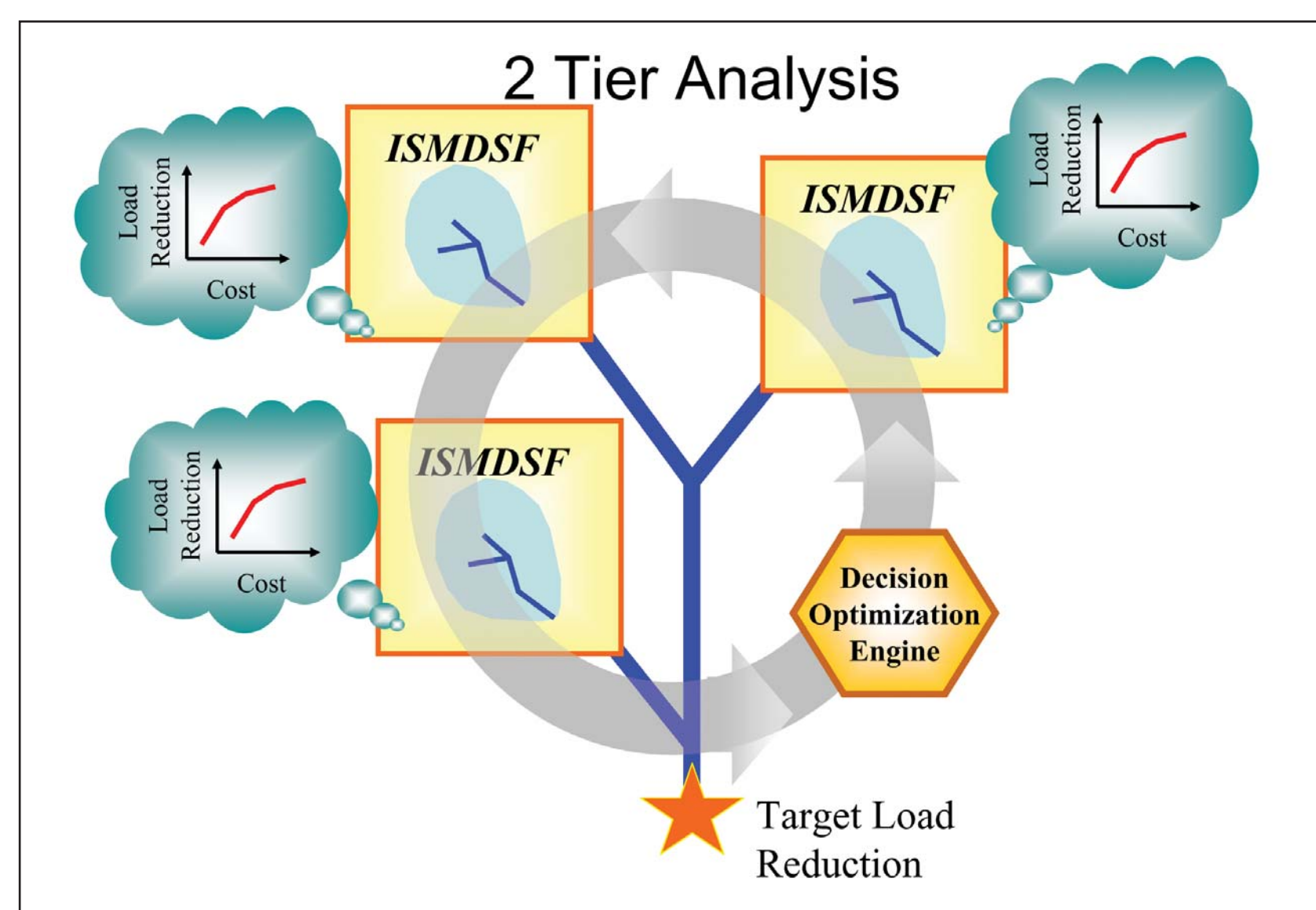
A relatively large watershed shown in the figure below can usually be subdivided into several smaller sub-watersheds. For each sub-watershed, users select an appropriate suite of feasible BMP options (types, configurations, and costs) at strategic locations. The ISMDSF generates time series rainfall-runoff data from BMP tributary areas and routes them through BMPs, in parallel or in series, and predicts quantity and quality at selected locations.



The ISMDSF produces data for deriving optimal production curves that relate flow or pollutant load reductions with costs as in the figure below. Each point on a curve represents an optimal combination of BMPs that will collectively remove the stated amount of pollutant load at the least cost.

The figure also shows a two-tier analysis that the ISMDSF will perform in a watershed:

- First-tier to develop an optimal production curve for each sub-watershed.
- Second-tier to consider all optimal production curves in the watershed to derive optimal combinations of BMP placement that meet the target load reduction for the watershed



Key Components and Their Functionalities

Seven key components shown below are integrated under a common ArcGIS platform.

- **Framework manager (FM)** - serves as the command center of the ISMDSF, managing the data exchanges between system components.

- **ArcGIS Interface** - serves as the main user interface that includes the main application window with menus, buttons, and dialog boxes.

- **Microsoft Access database** - consists of tables and queries for interaction and exchange of data.

- **Watershed module** - includes three internal stand-alone watershed models for generating flow and pollutant time series:

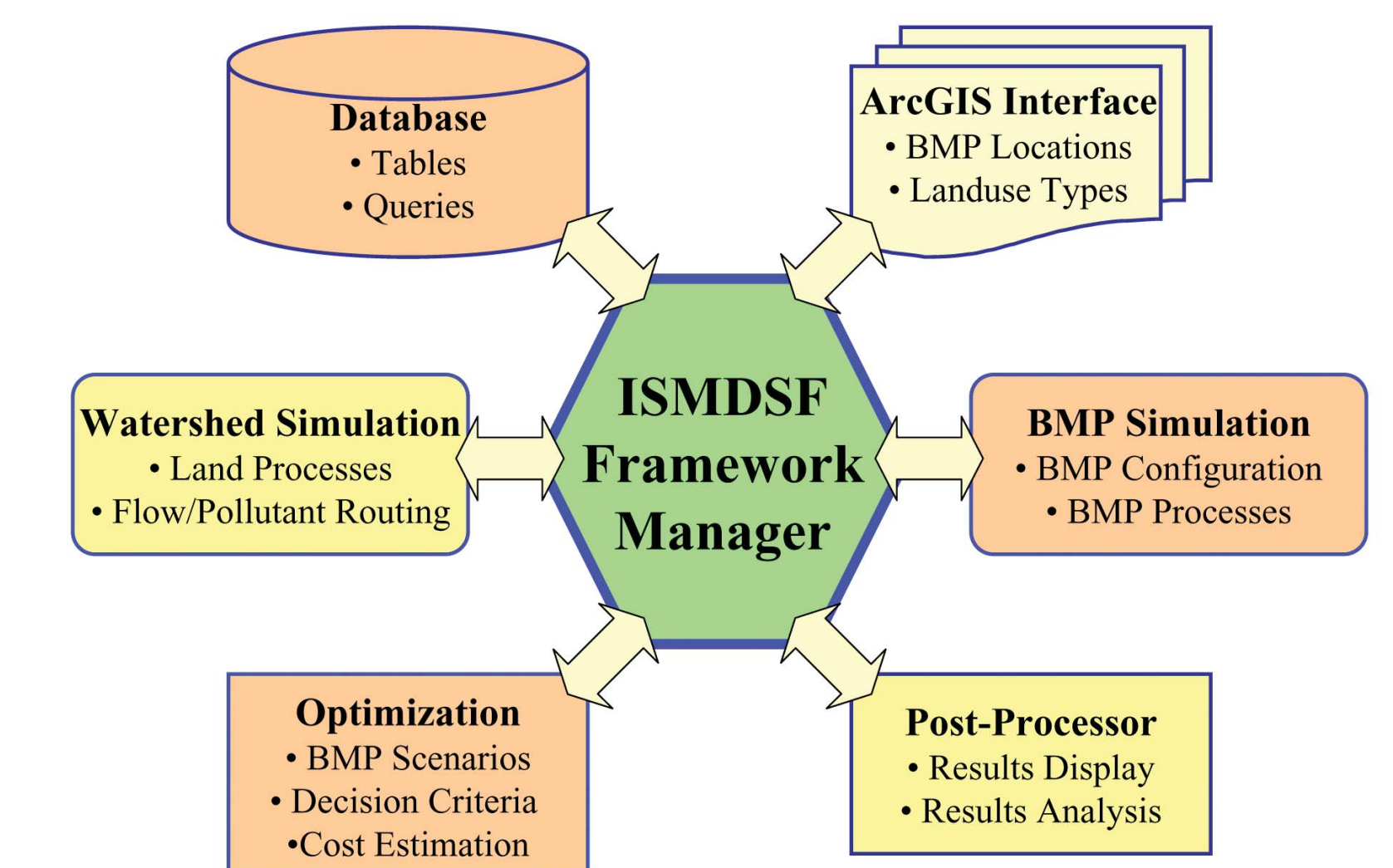
- **Land** for performing watershed/landscape runoff simulation.
- **Conduit** for routing of flow and pollutant through a conduit network.
- **Reach** for stream conveyance and pollutant routing.

The computer codes will be derived mostly from SWMM5 (USEPA 2004) and re-compiled into a dynamic link library (DLL) in the Visual Fortran platform.

- **BMP module** - performs process-based simulation to derive the performance of a BMP. The module builds on the Prince George's County BMP Module, which addresses five major structural BMP types and four major processes (Prince George's County 2001). The BMP processes are organized into two generic BMP classes: (a) storage/detention, and (b) channel-based.

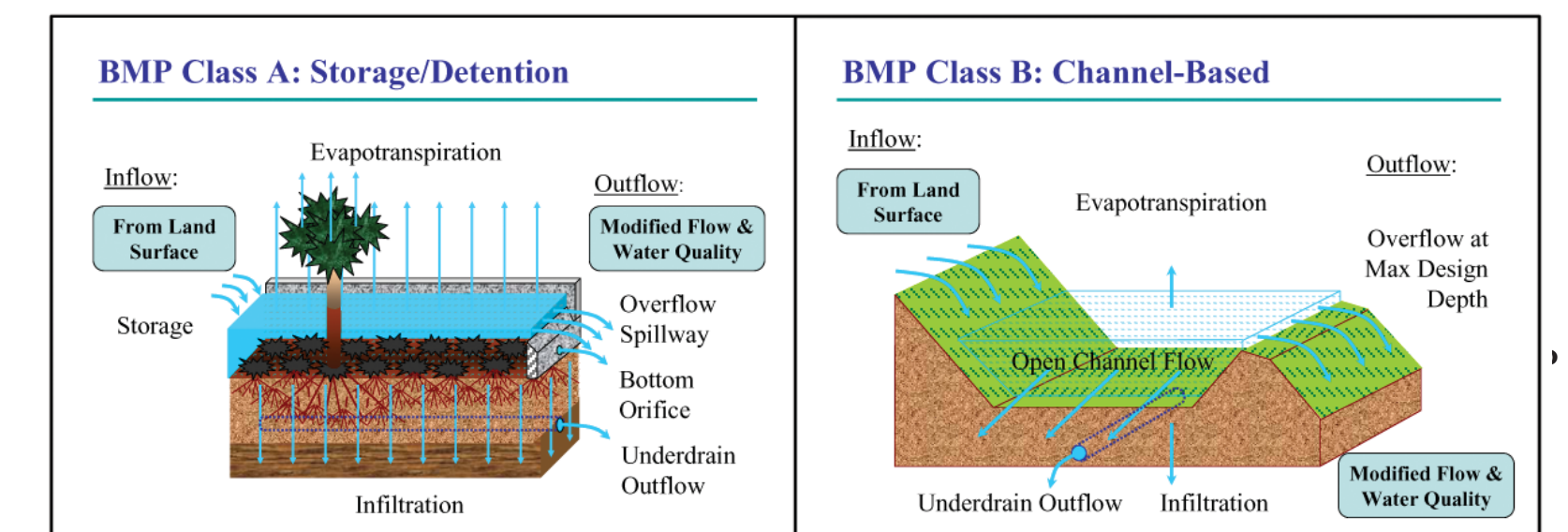
- **Post-processor** - uses Microsoft Excel to analyze and visualize model outputs.

- **Optimization module** - performs cost estimating and systematically compares performance and cost data of various BMP options and their placement scenarios.



| Structural BMP Types | Storage Routing | Infiltration /Filtration | Pollutant Routing/ Removal | Sheet Flow Routing/Pollutant Interception |
|----------------------|-----------------|--------------------------|----------------------------|---|
| Detention Basin | + | (o) | o | - |
| Bioretention Basin | o | + | o | - |
| Wetland | + | (o) | + | - |
| Buffer Strip | - | + | (o) | + |
| Swale | o | + | + | - |

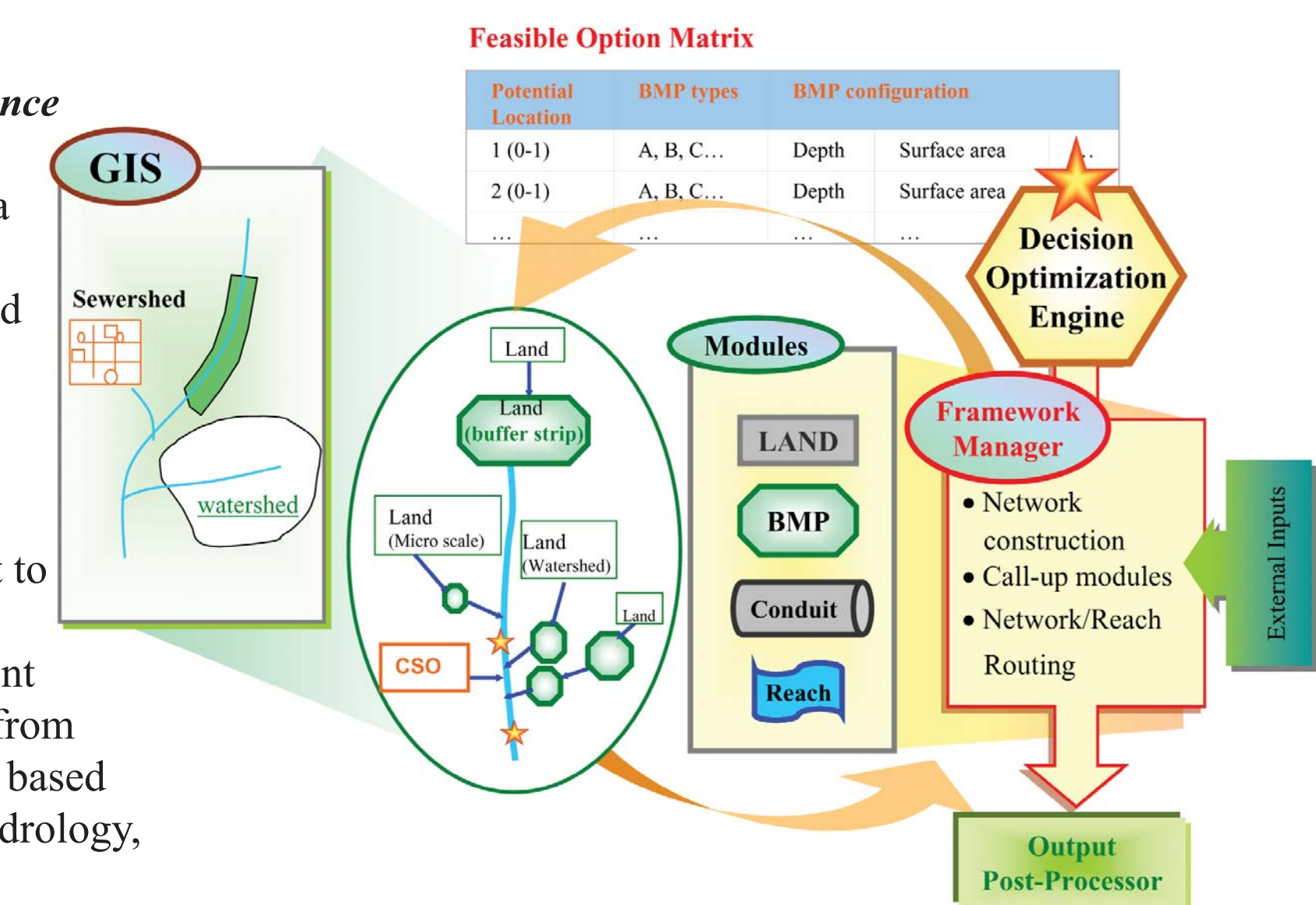
Notes: () optional; + major function; o secondary function; - insignificant function.



Operation of ISMDSF

The framework performs the following sequence of analyses:

- Beginning with ArcGIS view and database, a simulation network is developed.
- The FM identifies the modules to be used and prepares model input files.
- The FM routes the external inputs to appropriate modules and their outputs to the Output Post-Processor.
- Outputs from Output Post-Processor are sent to the Decision Optimization Engine.
- The Optimization Engine evaluates the current option and selects the next preferred option from that contained in the Feasible Option Matrix based on cost and defined decision criteria (i.e., hydrology, water quality).
- For a target load reduction from a watershed, the location and type of BMPs are varied and numerous iterations of the ISMDSF are performed.
- The iterations end when the convergence criteria are met.



Impacts/Outcomes

- This project demonstrates a collaborative effort of USEPA with a leading watershed modeling firm and a county known nationally for advancing the LID technologies.
- The watershed-based decision support tool would help develop restoration plans - that consider hydrologic and water quality impacts, and optimize cost and effectiveness.
- The tool will support USEPA program offices in stormwater management evaluations and cost optimizations.

References

- Prince George's County. (2001). *Low-Impact Development Management Practices Evaluation Computer Module, User's Guide*. Prepared by Tetra Tech, Inc., Fairfax, VA.
- U.S. Environmental Protection Agency (USEPA). (2004). Stormwater Management Model Redevelopment Project. <http://www.epa.gov/ednnrmrl/swmm/index.htm>.

Acknowledgement

USEPA Region 3 provided the funding to Prince George's County for improving the processes in the BMP model and developing an optimization model that will be incorporated into the ISMDSF.



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